Noteworthy ornithological records from the threatened *campinas* of the lower rio Tocantins, east Amazonian Brazil

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Summary.—Recent ornithological field work in previously poorly inventoried Amazonian enclaves of savanna and stunted forest have resulted in the discovery of many taxa previously thought absent from the biome and even undescribed species. Here we present ornithological observations of non-forest bird species from a series of *campina* physiognomies along the lower rio Tocantins in eastern Pará state, Brazilian Amazonia. Despite the area's relative proximity (*c.*90 km) to the state capital Belém (a long-term hub of Amazonian ornithology) we encountered several bird species previously unreported from the region. These included significant range extensions for species of conservation concern such as Ocellated Crake *Micropygia schomburgkii* and Rufous-sided Pygmy Tyrant *Euscarthmus rufomarginatus* (Near Threatened). We explore the biogeographical significance of these records in terms of postulated scenarios of colonisation of Amazonian savanna enclaves by non-forest species, and assess the threats that these communities face from current human activities.

Open-habitat enclaves are distributed patchily throughout lowland Amazonia, typically in areas with very leached and nutrient-poor sandy soils (Anderson 1981, Silva & Bates 2002). Their reduced structural complexity, patchy distribution, distinctive geomorphology and variable isolation from other 'source' patches mean that their biotas are often highly idiosyncratic and species-poor but distinguished by comparatively high rates of endemism (Anderson 1981). Renewed investment in ornithological surveys of these non-forest islands (e.g. Silva *et al.* 1997, Vasconcelos *et al.* 2011) has resulted in the discovery of many species previously thought absent from the biome and even the recent description of new range-restricted species (e.g. Cohn-Haft *et al.* 2013, Whitney *et al.* 2013). However major gaps remain in our knowledge of these disparate enclaves and plugging these 'Wallacean shortfalls' (*sensu* Lomolino & Heaney 2004) should be a conservation priority given rates of conversion and degradation of these unique ecosystems. Open-habitat enclaves on white-sand soils are often known as *campinas*, to differentiate them from open habitats on other soil types, e.g. savannas (e.g. Anderson 1981). *Campina* enclaves in the Brazilian Amazonian state of Pará are particularly poorly inventoried (Ferreira *et al.* 2013a,b). Although *c.*2% of the state is covered by *campina* formations (Ferreira *et al.* 2010), dedicated ornithological field work has apparently only been conducted on the large southern enclave of the Serra do Cachimbo (Pinto & Camargo 1957, Santos *et al.* 2011) and in the small fragmented *campina* north-east of Belém in the Zona Bragantina (Novaes & Lima 1992, Lees *et al.* 2014). This neglect is all the more serious considering the widespread loss and degradation of such *campina* habitats in easternmost Pará due to agricultural expansion and aggregate extraction (Vieira *et al.* 1967, Ferreira *et al.* 2013b).

A large complex of *campina* formations along the lower rio Tocantins, Pará, has apparently escaped modern ornithological field work and they were unmarked on the maps of principal Amazonian *campina* formations indicated in both Silva *et al.* (1997) and Aleixo &

Poletto (2007), although it has recently been explored by botanists (Ferreira *et al.* 2013b). We undertook ornithological field work along the lower Tocantins in September–October 2013, under the auspices of the 'Projeto INCT Biodiversidade e Uso da Terra na Amazônia' (CNPq / Museu Goeldi), whereby our primary aim was to establish the biodiversity consequences of rapidly expanding oil palm *Elacis guineensis* plantations in the region (Butler & Laurance 2009, Lees & Vieira 2013). During our quantitative field work we were able to conduct largely opportunistic surveys of *campina* enclaves, of which we present the principal findings here, contextualised via reference to the literature and historical specimens.

Methods

Study landscape: climate and biophysical conditions.—Regional climate is classified as Köppen-type Ami, with mean temperatures around 25ºC and relative humidity always >80%. Mean annual precipitation is *c.*2,200 mm concentrated between January and July (IDESP 2013). We identified two distinct *campina* physiognomies. In the municipalities of Moju and Tailândia were small pockets of tall-grass *campinas* (sward height *c.*30 cm; Fig. 2a) dominated by *Axonopus pubivarginatus* (Henr.), *Rhynchospora barbata* (Vahl.) Kunth, *Macrolobium bifolium* Persoon, *Lagenocarpus rigidu* (Kunth) Nees, and *Sauvagesia sprengelii* A. St.-Hil. Closer to the Tocantins on both banks (Fig. 2b) there were extensive *campinas* dominated by grassy formations with scattered gnarled Cerrado trees. Ferreira *et al.* (2010, 2013b) found this area to be dominated by herbaceous plants such as *Syngonanthus tenuis* var. *bulbifer* (Huber), *Paepalanthus fertilis* Körn. (Eriocaulaceae), *Rhynchospora barbata* (Vahl) Kunth and *Lagenocarpus rigidus* Nees (Cyperaceae).

Field work protocols.—Survey work was undertaken by ACL & NGM along the east bank of the rio Tocantins (Fig. 1), in the municipalities of Moju and Tailândia between 11 September and 1 October 2013, and on the west bank of the Tocantins at Cametá on 2–5 October 2013. Our primary aim was to understand the biodiversity value of forest remnants and adjoining agricultural landscapes (principally oil palm but also cattle pasture) within three drainage catchments Ubá (9,580 ha), Arauai (9,513 ha) and Mamorana (6,791 ha). Within each catchment, we used a stratified random sampling design following our previous avian sampling protocols (see Lees *et al.* 2012, 2013) to help ensure that sample data provide a representative assessment of overall environmental condition. In each catchment a standard density of 300-m study transects was distributed across the landscape in proportion to the percentage cover of forest (primary and secondary) and production.

Within each of these major land-use categories sample transects were distributed randomly to increase the likelihood that we captured important internal heterogeneities in forest and / or production systems. A minimum separation distance rule of 1,500 m between transects was employed to minimise dependence between points. Using this survey methodology just a single area of undisturbed *campina* vegetation was selected for quantitative sampling ('Moju 2': 02°14'S, 48°50'W; Fig 1). However, given the ornithological importance of this habitat evident from the sample, we made repeated visits to as many patches as possible outside survey periods (principally 'Moju 1': 12°14'S, 48°50'W; Fig. 1). During this initial survey we conducted two repetitions of three fixed-width (75 m) 15-minute point counts per transect sited at 150 m-intervals along a 300 m-transect. Surveys were not undertaken on days with persistent rain and / or strong winds. After completing our quantitative survey work on 1 October, we travelled west to Cametá sampling *campinas* (Fig. 1) identified using Google Earth (version 4.3) with field work concentrated at 'Cametá 1' (02°08'S, 49°34'W), 'Cametá 2' (02°17'S, 49°40'W) and 'Cametá 3'(02°18'S, 49°17'W).

We compiled all records of 'non-forest' bird species that are not associated with aquatic ecosystems, following the classifications of Aleixo & Poletto (2007) and Mittermeier *et al.*

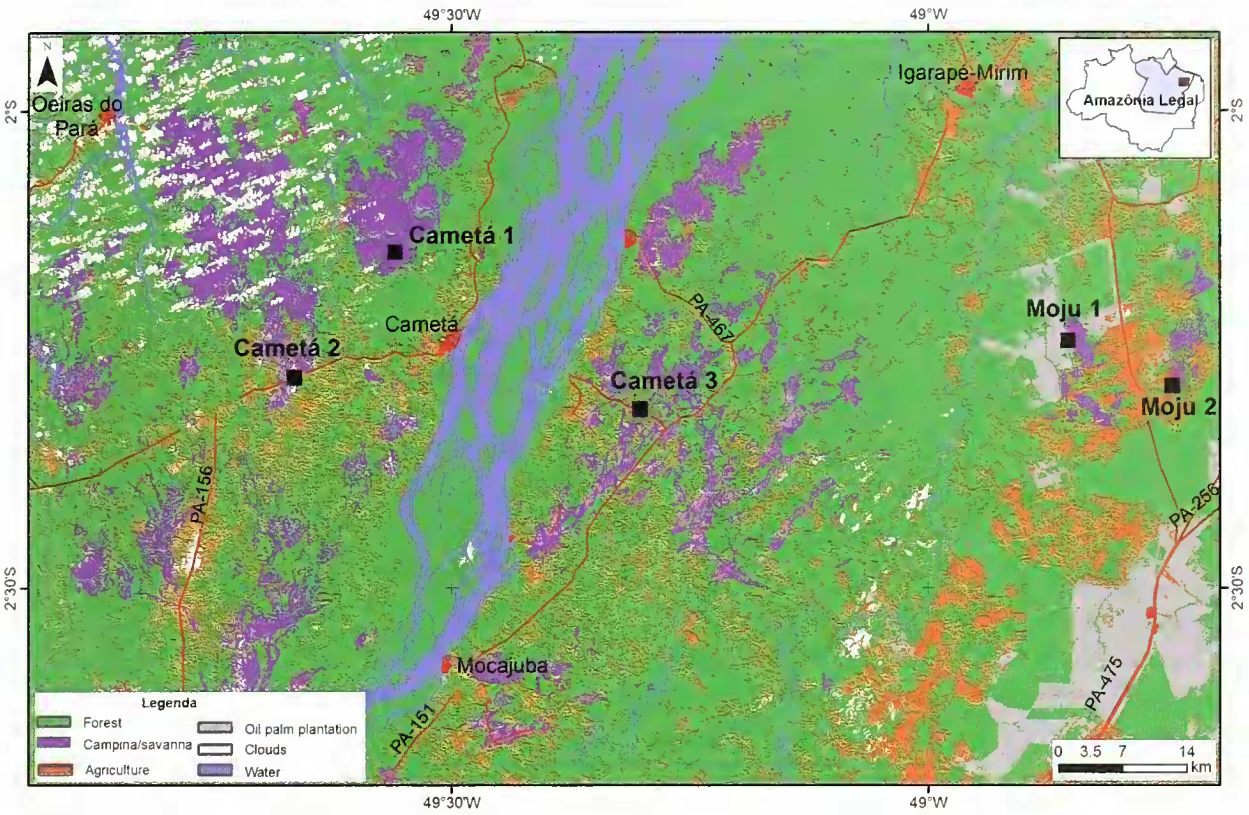

Figure 1. Map illustrating the position of the five principal sampling sites and major land-use types along the lower Tocantins.

Figure 2. (a) herbaceous *campina* at Moju, Pará; (b) arborescent *campina* at Cametá, Pará, Brazil, in October 2013; (c) aggregate extraction on the west bank of the Tocantins at Cametá in October 2013; (d) drainage ditches dug into *campina* at Carapajó on the east bank of the Tocantins in October 2013 (A. C. Lees).

TABLE 1

List of 56 open-habitat species recorded from the lower Tocantins region, south of the Amazon (Pará, Brazil). Photo- and sound-reference numbers refer to the online databases of www.wikiaves.com.br (WA) and www.xeno-canto.org (XC). Initials denote author records of species for which digital vouchers were not obtained. Habitat codes are as follows: C = *campina*, A = agriculture / silviculture (pasture, oil palm), U = urban.

Scientific name	English name	West bank	East bank	Habitat
Crypturellus parvirostris	Small-billed Tinamou		ACL, NGM	C,A
Bubulcus ibis	Cattle Egret	ACL, NGM	ACL, NGM	A
Coragyps atratus	Black Vulture	ACL, NGM	WA1240419	C,A,U
Elanus leucurus	White-tailed Kite		WA1240411	C,A
Heterospizias meridionalis	Savanna Hawk	ACL, NGM	WA1163992	C,A
Geranoaetus albicaudatus	White-tailed Hawk	ACL, NGM	WA1169115	C,A
Caracara plancus	Southern Caracara	ACL, NGM	WA1088715	C,A,U
Milvago chimachima	Yellow-headed Caracara	ACL, NGM	ACL, NGM	C,A,U
Falco sparverius	American Kestrel		ACL	U
Falco femoralis	Apolomado Falcon		ACL	A
Micropygia schomburgkii	Ocellated Crake		XC149795	C
Laterallus viridis	Russet-crowned Crake	ACL, NGM	ACL, NGM	C,A
Porzana albicollis	Ash-throated Crake	ACL, NGM	XC149795	C,A
Columbina passerina	Common Ground Dove	WA1241457	WA1167084	C,A,U
Colombina minuta	Plain-breasted Ground Dove	ACL, NGM	WA1170904	A
Columbina talpacoti	Ruddy Ground Dove	ACL, NGM	WA1170896	C,A,U
Patagioenas picazuro	Picazuro Pigeon		ACL, NGM	C,A
Zenaida auriculata	Eared Dove	ACL, NGM		C,U
Eupsittula aurea	Peach-fronted Parakeet	ACL, NGM		C
Crotophaga ani	Smooth-billed Ani	ACL, NGM	WA1163940	C,A,U
Guira guira	Guira Cuckoo		ACL, NGM	C,A,U
Tapera naevia	Striped Cuckoo	ACL, NGM	WA1163938	C,A
Tyto alba	Barn Owl		ACL, NGM	A
Athene cunicularia	Burrowing Owl	WA1177607	ACL, NGM	C,A
Hydropsalis torquata	Scissor-tailed Nightjar	ACL, NGM	ACL	C
Chordeiles pusillus	Least Nighthawk	XC150403	WA1108262	C
Chordeiles acutipennis	Lesser Nighthawk	ACL, NGM	WA1240426	C,A
Polytmus theresiae	Green-tailed Goldenthroat	ACL, NGM	ACL, NGM	C,A
Nystalus maculatus	Spot-throated Puffbird	ACL, NGM	WA1170899	C,A
Melanerpes candidus	White Woodpecker		WA1169115	C,A
Formicivora rufa	Rusty-backed Antwren	WA1108187	WA1088763	C,A
Synallaxis albescens	Pale-breasted Spinetail	WA1241456	WA1112846	C,A
Todirostrum cinereum	Common Tody-Flycatcher		ACL, NGM	C,A,U
Hemitriccus striaticollis	Stripe-necked Tody-Tyrant		ACL	C
Euscarthmus rufomarginatus	Rufous-sided Pygmy Tyrant		WA1088760	C
Elaenia cristata	Plain-crested Elaenia	ACL, NGM	WA1240441	C,A
Elaenia chiriquensis	Lesser Elaenia		WA1240443	C
Xolmis cinereus	Grey Monjita	WA1111923		C
Casiornis fuscus	Ash-throated Casiornis		WA1088730	C
Myiozetetes cayanensis	Rusty-margined Flycatcher	ACL, NGM	ACL, NGM	C,A,U

Anthus lutescens	Yellowish Pipit	ACL, NGM	WA909541	C
Saltator azarae	Amazonian Greyish Saltator	ACL, NGM	ACL, NGM	C,A
Tachyphonus rufus	White-lined Tanager	ACL, NGM	WA1170903	C,A,U
Schistochlamys melanopis	Black-faced Tanager	WA1177611	WA1170898	C,A
Schistochlamys ruficapillus	Cinnamon Tanager		WA1088770	C
Zonotrichia capensis	Rufous-collared Sparrow	ACL, NGM	WA909543	C,A
Amnodramus humeralis	Grassland Sparrow	WA1177622	WA1240413	C,A,U
Ammodramus aurifrons	Yellow-browed Sparrow	ACL, NGM	WA1175341	C,A
Emberizoides herbicola	Wedge-tailed Grass Finch	WA1241455	WA1167085	C,A
Sporophila plumbea	Plumbeous Seedeater	ACL, NGM	WA1163939	C,A
Sporophila americana	Wing-barred Seedeater	ACL, NGM	WA1240420	C,A
Sporophila nigricollis	Yellow-bellied Seedeater	ZMB 31220	WA1088728	C,A
Sporophila minuta	Ruddy-breasted Seedeater	ACL, NGM	WA1167086	C,A
Sporophila angolensis	Chestnut-bellied Seed Finch		WA1175376	C,A
Geothlypis aequinoctialis	Masked Yellowthroat	ACL, NGM	WA1169108	C,A
Sturnella militaris	Red-breasted Blackbird	ACL, NGM	WA909544	C,A

(2010).We archived digital vouchers (photographs and sound-recording e-vouchers) on the internet to provide documentary evidence for species mentioned in the accounts. Images have been archived on the Brazilian archive WikiAves (www.wikiaves.com.br) and our sound-recordings on the global avian sound library xeno-canto (www.xenocanto.org). Material on both sites is searchable by the catalogue number provided in the text.

We compiled a list of specimens collected by previous field workers from the Museu Paraense Emílio Goeldi, Belém, Brazil (MPEG)—some of which are now held at the Museum für Naturkunde, Berlin (ZMB) and the Museu Nacional do Rio de Janeiro (MNRJ)—and used the digital database ORNIS www.ornisnet.org/ to search for other historical specimens. These searches retrieved relevant records in the collections of the American Museum of Natural History, New York (AMNH), Field Museum of Natural History, Chicago (FMNH) and Los Angeles County Museum of Natural History (LACM). Historic collecting localities were located using Paynter & Traylor (1991). Our taxonomy follows that of the Comitê Brasileiro de Registros Ornitológicos (CBRO 2014).

Results

Our quantitative and qualitative bird surveys produced records of 56 non-forest bird species (Table 1). Such species were not necessarily restricted to *campina* habitats, with some also occupying cattle pastures and oil palm plantations, a separate quantitative evaluation of these trends will be published elsewhere (Lees in prep.). We present species accounts for the most noteworthy records below.

OCELLATED CRAKE *Micropygia schomburgkii*

ACL sound-recorded (XC149795) a single spontaneously vocalising individual from a tall-grass *campina* formation that had been planted with oil palms in the municipality of Moju, 'Moju 1', on 11 September 2013. The plantation was three years old but owing to the poor quality sandy soil had failed to flourish and *campina* grassland flora was well preserved between the rows of palms. We subsequently located a second territory 800 m from the first on 13 September 2013 in an open tall-grass *campina* physiognomy close to a stand of *Mauritiella armata* (Mart.) Burret palms. Our final record concerned a single that sang in

Figure 3. (a) female Rusty-backed Antwren *Formicivora rufa*, Cametá, Pará, Brazil, 3 October 2013; (b) Rufous-sided Pygmy Tyrant *Euscarthmus rufomarginatus*, Moju, Pará, Brazil, 13 September 2013; (c) juvenile Grey Monjita *Xolmis cinereus* Cametá, Pará, Brazil, 3 October 2013; (d) pair of Cinnamon Tanagers *Schistochlamys ruficapillus* with Black-faced Tanager *Schistochlamys melanopis*, Moju, Pará, Brazil, 12 September 2013 (A. C. Lees)

response to playback 3.6 km south of the second site (and in a similar habitat type) at 02°16'S, 48°49'W, on 18 November 2013 (XC155521). These birds' habitat choice is closely allied to that in Cerrado reported by Negret & Teixeira (1984), who found that Ocellated Crakes preferred dense dry grasslands dominated by *Tristachya leiostachya* (Graminae), adjacent to wetter palm groves or gallery forests, although the species often occurs in grasslands far from watercourses (A. Whittaker *in litt.* 2014). Although currently ranked as Least Concern by BirdLife International, all species restricted to humid *cerrado* are probably under threat (www.icmbio.gov.br/portal/biodiversidade/fauna-brasileira/planos-de-acao/3618-plano-de-acao-nacional-para-a-conservacao-das-aves-do-cerrado-e-pantanal.html).

The only previous record in the state is apparently that listed by Lopes *et al.* (2010) from 'Pará, Rio Cuminá, afluente do Rio Trombetas' citing a rather ambiguous text in Miranda-Ribeiro (1937). However, the undated label on the specimen (MNRJ 16.302) reads 'Rio Trombetas, Cuminá, Mato Grosso. col. Rondon' (G. R. Brito *in litt.* 2014), presumably in error, but some doubt remains over its provenance. We consider ours to be the first unambiguous records for the state of Pará and certainly the first south of the Amazon. Elsewhere in southern Brazilian Amazonia the species has been recorded at several localities in south-west Mato Grosso, e.g. the Chapada dos Parecis (LACM 46320), Serra do Roncador (Fry 1970), Morrinho Lyra (Naumburg 1930), Vila Bela da Santíssima Trindade (Lopes *et al.* 2010) and Serra das Araras (Silva *et al.* 1988), as well as in neighbouring Rondônia at the Campo dos Palmares, headwaters of the rio Javari, Chapada dos Parecis (Miranda-Ribeiro

1937), at the Fragmento RO-7, Pimenta Bueno, and Fragmento RO-1, Vilhena (Roma 2006 *in* Lopes *et al.* 2010) and at Humaitá, Amazonas, where D. C. Pimentel collected one (MPEG 49443) on the BR-230, km 8, on 17 October 1991, and A. Whittaker (*in litt.* 2014) discovered a nest with two eggs on 13 January 2011.

PLAIN-BREASTED GROUND DOVE *Columbina minuta*

Our only confirmed record involved a pair photographed in a recently planted oil palm plantation at Fazenda Recanto (02°53'S, 49°11'W) in the municipality of Moju on 25 September 2013 (WA1175343, WA1170904). This represents only the second record from the Belém Area of Endemism, after a series of five individuals (FMNH 411441–445) collected on the rio Acará at Tomé-Açu between 4 and 23 December 1933. Elsewhere in south-east Pará, the species is known from a male (MPEG 14108) collected by J. Hidasi on the rio Fresco (a right-bank tributary of the rio Xingu) at Gorotire (07°46'S, 51°07'W) on 7 September 1957, and two recent photographic records from the middle Xingu at Senador José Porfírio (C. V. Mendonça: WA990130) and Vitória do Xingu (A. E. Rupp: WA920294), as well as the Santarém region (Lees *et al.* 2013). Aleixo *et al.* (2012) listed the species from the Floresta Nacional de Carajás based on a single undocumented record so its presence there should be considered hypothetical (A. Aleixo *in litt.* 2014).

LEAST NIGHTHAWK *Chordeiles pusillus*

Common in grassy *campinas* around Moju, for example >15 individuals at dawn on 12 September 2013 at 'Moju 2' (WA1108262) and six on the left bank of the Tocantins at Cametá on 3 October 2013 (e.g. XC150403). In Amazonia, the species is restricted to open-vegetation enclaves (savannas and *campinas*), such as in Amapá (Silva *et al.* 1997), Rupununi, Guyana / Roraima (Robbins *et al.* 2004, Santos & Silva 2007), Jaú National Park (Borges *et al.* 2001) and the upper rio Marmelos, Amazonas (Aleixo & Poletto 2007), and the Sipaliwini Savanna, Surinam (O'Shea 2005, Mittermeier *et al.* 2010). The nearest documented record concerns one collected (AMNH 430372) at Baião, on the rio Tocantins, on 1 December 1931 by A. M. Ollala.

RUSTY-BACKED ANTWREN *Formicivora rufa*

We first found this species in a *campina* planted with oil palms at 'Moju 1' on 11 September 2013 (WA1088763) and subsequently in all suitable *campina* habitats in the same municipality and adjacent Tailândia. We also found it in savannas either side of the Tocantins in the municipality of Cametá (e.g. Fig. 3a; WA1108187). It is present in most *campina* enclaves in Amazonia but has been reported from the Belém Area of Endemism only once before, along the rio Acará, where H. Meerwarth collected one in December 1898 (MPEG 1665). Although details are vague, this is conceivably close to the *campina* formations we sampled around Moju. However, there are more historic records from the west bank of the rio Tocantins, e.g. three specimens (MPEG 11991–11993) taken by F. Lima at the Campo de Pacurijó, Cametá on 3 and 22 February 1916. We anticipate that it will prove to be considerably more widespread than these scant records suggest.

RUFOUS-SIDED PYGMY TYRANT *Euscarthmus rufomarginatus*

During point counts at dawn in an open *campina* physiognomy at 'Moju 2', on 12 September 2013, ACL heard the distinctive song of a pair of Rufous-sided Pygmy Tyrants and obtained some distant photographs. ACL & NGM returned the following day, securing better-quality images (e.g. Fig. 3b; WA1088760) and sound-recordings after playback (e.g. XC150393) of presumably the same pair *c.*200 m from their position of the day before. ACL & NGM

located another territory at a different *campina* 12 km west-northwest of 'Moju 1' on 14 September 2013. We conducted playback in several arborescent *campinas* on both banks of the Tocantins in the municipality of Cametá, but did not find the species there, although we infer its potential presence given the availability of *campina* of the same physiognomy as our records at Moju and the difficulty of finding this low-density species. Our records represent the fourth locality in the state of Pará. Previous records are from the Serra do Cachimbo on the border with Mato Grosso (Pinto & Camargo 1957, Santos *et al.* 2011), Campos do Rio Vermelho (07°39'S, 51°37'W) in the Terra Indígena Kaiapó (Whitney & Pacheco 1996; B. M. Whitney *in litt.* 2013) and nearby at the Aldeia Kuben-Kran-Krên (08°08'S, 52°07'W) on 24–30 April 2008 (A. Whittaker *in litt.* 2014). Elsewhere in Amazonia the species is known from three other *campina* enclaves: the Sipaliwini Savanna in southern Surinam (Mees 1968, Mittermeier *et al.* 2010), 48 km north of Macapá, Amapá, Brazil (Silva *et al.* 1997) and at Manicoré, Fazenda Bela Vista, Amazonas, at 08°31'S, 61°24'W (MPEG 57705; Aleixo & Poletto 2007). The closest-known localities are, however, in the Cerrado biome south-west of the region. T. Dornas photographed (WA456401) one along the TO-134 highway in the municipality of Darcinópolis, Tocantins, in Cerrado *sensu stricto* on sandy soils, on 17 May 2009, although this area has subsequently been converted to a *Eucalyptus* plantation. The species has declined across most of its range due to the loss of well-preserved Cerrado (Parker & Willis 1997) and is currently considered Near Threatened globally (Birdlife International 2014).

GREY MONJITA *Xolmis cinereus*

Fairly common in savannas on the west bank of the Tocantins at Cametá (Fig. 1; Cametá 1 and 2) between 2 and 4 October 2013 (e.g. Fig. 3c; WA1112847, XC150402). We did not encounter the species in the smaller enclaves around Moju and are reasonably confident that it does not occur there, but we did not spend significant time surveying arborescent *campina* on the east bank of the Tocantins, and given the similar habitat there and on the west bank, we anticipate its potential presence there. It is surprising that this large and conspicuous passerine was not reported by E. Snethlage, S. Klages or the Olalla brothers, all of whom collected along the lower Tocantins, raising the possibility that this region may have been only recently colonised or re-colonised by the species. These are the first published reports from the lower Tocantins, although it occurs 475 km to the south around Canaã dos Carajás (Aleixo *et al.* 2012; J. G. Vilar: WA1005020) and 80 km to the north-east on Marajó Island (Henriques & Oren 1997). There is a single record from Belém at the Federal University campus in 1984, which was considered by Silva & Oren (1986) to be a vagrant from Marajó. Our discovery along the lower Tocantins raises the possibility of an alternative origin for the Belém vagrant and hints at occasional inter-enclave movements by these open-habitat specialists in Amazonia.

CINNAMON TANAGER *Schistochlamys ruficapillus*

We recorded this species at two different *campinas* in the municipality of Moju; one seen briefly on 11 September 2013 at 'Moju 1' and next day a pair was photographed at 'Moju 2' (Fig. 3d; WA1088770). These records represent a range extension 180 km north-east of the species' previous northernmost outpost at Tucuruí, Pará, where five specimens (MPEG 34351–355) were collected by D. C. Oren on 9–14 June 1980. Elsewhere in the state, away from the Serra do Cachimbo (e.g. Santos *et al.* 2011; WA348952), J. Hidasi collected one (MPEG 15032) on the rio Tapajós at Itaituba, on 11 November 1955, and another on the upper rio Cururu, a right-bank tributary of the rio Tapajós (MPEG 23144) in June 1958.

PLUMBEOUS SEEDEATER *Sporophila plumbea*
Common in both *campinas* and degraded pastures around Moju (e.g. WA1240426) principally on land owned by oil palm companies, whose patrols apparently deter the presence of the ubiquitous bird trappers (A. P. Brito & P. Zanutto pers. comm.). There are relatively few records from savanna enclaves in Amazonia, although the species has previously been reported from the Agropalma Group Forest reserves by Portes *et al.* (2011) and occurs on Marajó Island (Henriques & Oren 1997; WA520959), at Aldeia Kuben-Kran-Krên (A. Whittaker *in litt.* 2014) and the Serra do Cachimbo (Pinto & Camargo 1957).

Discussion

Our field work produced several significant range extensions for savanna species along the lower Tocantins, which is extremely surprising given proximity to the state capital and the 200-year history of ornithological research in the region (Moura *et al.* 2014). Our inventory should be considered extremely preliminary given that huge areas of unsurveyed *campinas* are present in the region, and we anticipate significant ornithological discoveries in such habitats in the future. For example, we searched extensively for Eastern Meadowlark *Sturnella magna* in *campinas* on both sides of the Tocantins, but only encountered small numbers of Red-breasted Blackbirds *S. militaris*. However, there are at least two historical records from the region: two collected by F. Lima on the west bank at Cametá in 1916, one at Fazenda Vaicajó (02°15′S, 49°29′W) on 3 February (ZMB 31289) and the other at Campo de Pacurijó (02°25′S, 49°5′W) on 22 February (held at MNRJ). There are also relatively extensive tracts of unsurveyed transitional forest in the region that may also yield significant ornithological surprises. For example, we (ACL, NGM & I. Thompson) recently visited tall *terra firme* forest 100 km south of Tailândia at Goianésia do Pará where we encountered an undescribed *Myiornis* pygmy tyrant (ACL: XC155227) recently collected in Maranhão and Piauí (C. Albano & L. Lima *in litt.* 2013) and an adult Black-faced Hawk *Leucopternis melanops* (ACL: WA1162085, XC155500). The latter is only the second record for the Belém Area of Endemism following one (MZUSP 43863) collected on the rio Capim, on the BR-14 highway, km 93, on 2 October 1959 (Amaral *et al.* 2007).

Threats to savanna enclaves on the lower Tocantins.—Savanna enclaves contribute significantly to regional betadiversity in Amazonia and support species of conservation concern whose habitats are under increasing pressure outside the biome, e.g. Rufous-sided Pygmy Tyrant (Klink & Machado 2005, Aleixo & Poletto 2007). *Campinas* along the lower Tocantins are under threat from aggregate extractors, agricultural and biofuel expansion, fire and drainage (Fig. 2c–d; Ferreira *et al.* 2013a,b). These habitats are poorly represented under the current Amazonian protected area network, with the nearest units being the Reserva Extrativista Arióca-Pruanã (59,600 ha) and Terra Indígena Anambé (21,700 ha), neither of which protects open-habitat physiognomies. We echo the pleas of Ferreira *et al.* (2010, 2013b) to create new protected areas to safeguard the region's biodiversity under the auspices of an Área de Relevante Interesse Ecológico (ARIE).

Regional biogeographic implications.—The question of how open-country bird species disperse through Amazonia to reach isolated open-habitat enclaves has vexed biogeographers for decades (Haffer 1967, 2001). Silva & Bates (2002) proposed three principal corridors that facilitated past connections between predominantly open habitats in central Brazil and Bolivia and northern South America: (1) an Andean corridor following the slopes of the Andes to the west of Amazonia; (2) a central Amazonian corridor via Monte Alegre and the Sipaliwini–Pará *campinas*; and (3) a corridor along the Atlantic coast north via *restinga* enclaves in north-east Pará, to Marajó Island and through the savannas of Amapá. Mittermeier *et al.* (2010) considered that the 'high number of CSA-unique [central

South American] species in Sipaliwini and Amapá, as opposed to Alter do Chão [near Santarém] supports the hypothesis that savanna connections within the southern block formed along the coast rather than across central Amazonia' citing Silva & Bates (2002). However, their comparison of lists relied on that compiled by Sanaiotti & Cintra (2001), which represented only a rapid inventory of Alter do Chão. An additional 33 open-country species have been reliably recorded there (Lees *et al.* 2013), 22 of which are shared between regions, seven are exclusively 'central' and four exclusively northern.

Our discoveries of open-habitat species along the lower Tocantins support another route, following enclave 'stepping stones' from the Cerrado in Tocantins north to Marajó Island, and highlight the difficulties of understanding the historic biogeography of Amazonia in the face of Wallacean shortfalls, in addition to the imminent threat that this unique avifaunal assemblages faces from land-use change and habitat degradation.

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